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ABSTRACT

Volunteer college students were assigned to one of six computer administered vocabulary tests, one half with immediate knowledge of results (KR) after responding to each item, and the other half without knowledge of results. The six tests were designed to be at one of three levels of difficulty and consisted either of 50 preselected items (conventional testing) or tailored on the basis of previous candidate responses (stradaptive testing). Results indicated that the mean maximum-likelihood estimates of individuals' ability varied as a joint function of the KR condition and of test difficulty. Students in the KR condition scored higher than the other students on the most difficult test and lower on the least difficult test. Questionnaire results indicated that, although the students perceived the differences in test difficulty, there were not shown to be any effects on mean student anxiety or motivation scores attributable to test difficulty alone. Students in general reacted very favorably to receiving immediate knowledge of results and its provision increased the mean level of reported motivation. (Author/CTM)

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THE EFFECTS OF KNOWLEDGE OF RESULTS AND TEST DIFFICULTY ON ABILITY TEST PERFORMANCE AND PSYCHOLOGICAL REACTIONS TO TESTING

J. Stephen Prestwood
and
David J. Weiss

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computerized testing	tailored testing	test feedback
adaptive testing	programmed testing	knowledge of results
sequential testing	response-contingent testing	test reactions

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Students were administered one of three conventional or one of three stradaptive vocabulary tests with or without knowledge of results (KR). The three tests of each type differed in difficulty, as assessed by the expected proportion of correct responses to the test items. Results indicated that the mean maximum-likelihood estimates of individuals' abilities varied as a joint function of KR-provision and test difficulty. Students receiving KR scored highest on the most-difficult test and lowest on the least-difficult test; students receiving no KR scored highest on the least-difficult test

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and did most poorly on the most-difficult test. Although the students perceived the differences in test difficulty, there were no effects on mean student anxiety or motivation scores attributable to difficulty alone. Regardless of test difficulty, students reacted very favorably to receiving KR, and its provision increased the mean level of reported motivation.

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The Effects of Knowledge of Results and Test Difficulty on Ability Test Performance and Psychological Reactions to Testing

Sufficient motivation is necessary in order to adequately measure an individual's ability (e.g., Cronbach, 1970; Samuda, 1975; Terman, 1916). The provision of immediate feedback or "knowledge of results" (KR) during testing is one possible method for increasing or maintaining high levels of motivation (Bayroff, 1964; Betz, 1975; Betz & Weiss, 1976b; Ferguson & Hsu, 1971; Strang & Rust, 1973; Zontine, Richards, & Strang, 1972). On-line computerized testing has made the provision of KR a relatively simple matter; the ease with which KR can be administered is an added advantage of computerized adaptive testing, which lies beyond the purely psychometric benefits of such procedures.

To study the effects and possible benefits of computer-administered KR, Betz and Weiss (1976a, 1976b) administered multiple-choice tests of verbal ability to college undergraduates at the University of Minnesota; the tests were administered either with or without KR after each item response. Their data showed higher testee performance, as measured by maximum likelihood ability estimates, for all students in the KR condition and significantly higher performance levels for low-ability students. Perceptions of test difficulty were more accurate for students receiving KR; these students also exhibited higher levels of motivation, as assessed by post-test measurements. The data also indicated that students' reactions to the provision of KR became more favorable as the proportion of *positive* feedback increased. Because KR increased performance and motivation in the Betz and Weiss studies and because individuals reacted more favorably to the provision of KR as the proportion of positive feedback increased, an analysis of the joint effects of provision of KR and the proportion of positive feedback (test difficulty) was initiated.

Method

Procedure

Subjects. Participating in this study were 561 undergraduate students enrolled in an introductory psychology course at the University of Minnesota in the fall of 1975. All students were volunteers who received points towards their final course grade for participation in the experiment. Students were sequentially assigned to experimental conditions.

Test administration. All students were tested at individual cathode-ray terminals (CRTs) connected to a Hewlett-Packard 9600E Real-Time computer system. Instructional screens explaining the operation of the CRTs preceded the actual testing and were similar to those described in DeWitt and Weiss (1974, pp. 36-53). In addition, students were informed that they would have as much time as they needed to finish the test. A proctor was present in the testing room to provide assistance in the operation of the equipment.

Each test consisted of 50 five-alternative multiple-choice items. During the test, items were presented on the CRT screen and students responded by typing in a number corresponding to the chosen alternative for each item. Following the test, the students were asked to indicate their feelings about the test by responding to a series of questions designed to assess their psychological reactions to the test. Students not provided KR were asked 18 questions, while those receiving KR were asked the same 18 questions plus an additional 8 questions concerning their reactions to the provision of KR.

Design

Independent variables. A three-way factorial design was employed in the study. One factor was immediate knowledge of results (KR). Students in the KR condition were informed by the computer immediately after their response to a question whether the reponse was correct or incorrect. After an incorrect response, they were told which of the alternatives was correct. Students in the no-KR condition received no feedback. Ability-test strategy was another factor. Individuals received either a conventional peaked ability test or a fixed-length stradaptive ability test (Weiss, 1973). A third factor was test difficulty or proportion of positive feedback. Three conventional tests and three stradaptive test-administration procedures were designed such that students, on the average, would answer approximately 40%, 60%, or 80% of the test questions correctly. Level of difficulty (high, medium, or low) was inversely related to the proportion of positive feedback an individual received, whether that feedback was explicit as in the KR condition or subjective as in the no-KR condition.

Dependent variables. Both the ability-test performance and the psychological reactions of the testees were of interest. Performance was measured by maximum likelihood ability estimates computed for each individual by solving the likelihood equation for Birnbaum's (1968, p. 459) three-parameter logistic model. Proportion-correct scores were also computed in order to assure that the tests were of appropriate difficulty. Proportion correct, however, was not used as an ability measure per se, since the stradaptive test-administration procedure was designed to yield an arbitrary proportion correct for each student and since differences in proportion-correct scores between students administered the three different conventional tests were determined to a degree by the construction of those tests.

The reactions of individuals to the tests were determined using the responses of the students to psychological reactions items administered following the test. The four scales constructed from these items measured students' perceptions of the test's difficulty; their level of anxiety during testing; their motivation to do well on the test; and, for testees in the KR conditions, their reactions to the provision of KR. The items in the Difficulty-Perception, Anxiety, Motivation, and KR-Reaction scales are shown in Appendix Tables A through D, respectively. Also shown are the serial positions of the items in the post-test battery of items. Response options on the Difficulty-Perception, Anxiety, and Motivation scales were weighted on a scale from 1 to 5, while those on the KR-Reaction scale were weighted on a scale from 1 to 4. These weights are also shown in the appendix tables. The scales were scored so that increasing scale scores corresponded to increasing anxiety, increasing motivation, perceptions of increasing difficulty, or increasingly positive reactions to KR.

Test Construction

Item pool. The item pool from which the tests were constructed consisted of 569 five-alternative multiple-choice vocabulary items. Each item had associated with it a normal-ogive discrimination (a) and difficulty (b) parameter estimate (Lord & Novick, 1968). These parameters were based on data derived from samples of University of Minnesota undergraduate students. The norming sample and the original norming procedures are described in McBride and Weiss (1974). Each of the five-alternative items was assumed to have a guessing parameter (c) of .20.

Conventional tests. Items were chosen for the three 50-item peaked conventional tests so that the mean normal-ogive discriminations would be equal (approximately a=.80) and the mean normal-ogive difficulties would be approximately b=-2.00, -.35, and 1.30 for the low-, medium-, and high-difficulty tests, respectively.

Stradaptive tests. In order to form a stratified item pool for adaptive testing (Weiss, 1973), items ranging in difficulty from b=-3.0 to b=+3.0 were grouped into nine non-overlapping strata on the basis of their difficulty-parameter estimates. The difference between the lowest and the highest difficulty in a stratum was constant at b=.67. Within a stratum, items were arranged in descending order of their discrimination-parameter estimates. A stratum contained at most 30 items, and no items were included with discrimination-parameter estimates of less than .30.

In a stradaptive test, branching between items is usually determined by whether an individual's response to the immediately preceding item was correct or incorrect (Weiss, 1973). The stradaptive administration procedure was modified in this study so that branching to a more (or less) difficult item was based on whether the individual's overall proportion correct was over (or under) a target value. In order to achieve average proportion-correct scores of .40, .60, and .80 for the low-, medium-, and high-difficulty tests, target values of .36, .60, and .84 were employed for the three tests, respectively. The target values were determined from a prior analysis of simulated responding. Branching was terminated after the administration of 50 items.

Revised parameter estimates. During the interval between the construction of the tests and the analysis of these data, the item-parameter estimates were revised according to a procedure outlined in Prestwood and Weiss (1977, Appendix A). The parameter estimates for items in the three conventional tests are shown in Appendix Table E. The mean b's for the low-, medium-, and high-difficulty tests were -2.32, -.70, and .68, respectively. The mean a's for the low-, medium-, and high-difficulty tests were .65, 1.07, and 1.76. An inspection of the revised item parameters for the items in the stratified item pool designed for stradaptive tests (Appendix Table F) shows some minor overlap in difficulties between adjacent strata and some departure from the descending order of discriminations within a stratum. The stratified pool, however, generally corresponds very closely to the desired structure specified for a stradaptive test.

Data Analysis

Proportion-correct measures. The proportion of items correctly answered was calculated for each student. The mean and standard deviation of these measures

were then calculated for each of the 12 experimental conditions in order to assess the accuracy with which the conventional and stradaptive tests yielded the desired levels of test difficulty.

Ability estimates. A maximum-likelihood estimate of ability was calculated for each individual, using the item parameters shown in Appendix Tables E and F. The mean and standard deviation of these estimates were calculated for each experimental condition and each combination of conditions. A classical three-way factorial analysis of variance was then performed on the data in order to assess the effects of KR-provision, test strategy, and test difficulty on mean student performance.

Psychological reactions. The means and standard deviations of scores on the four psychological reactions scales were calculated for all experimental treatments and for all combinations of treatments. The effects of KR-provision, test strategy, and test difficulty on mean Difficulty-Perception, Anxiety, and Motivation scores were assessed by three-way factorial analyses of variance. A two-way factorial analysis of variance was performed on data from the KR-Reaction scale. This analysis investigated the effects of test strategy and test difficulty on individuals' reactions to KR for those students in the KR conditions. Relative frequencies of response option endorsements were also calculated for items on the KR-Reaction scale.

Cronbach's α reliability coefficient was calculated for each of the psychological reactions scales. In addition, the inter-scale Pearson product-moment correlation coefficients were computed.

Results

Ability Test Data

Proportion correct. Table 1 shows the means and standard deviations of the proportion-correct measures for each experimental condition. Inspection of the

Table 1
Means and Standard Deviations of Proportion Correct for Conventional and Stradaptive Tests With and Without KR at Three Levels of Difficulty

Experimental Condition	Test Difficulty	Experimental Condition: KR			Experimental Condition: No-KR		
		N	Mean	S.D.	*N*	Mean	S.D.
Conventional Test							
Low Difficulty	.800	48	.783	.106	45	.808	.103
Medium Difficulty	.600	47	.608	.147	49	.592	.141
High Difficulty	.400	46	.451	.188	46	.364	.153
Stradaptive Test							
Low Difficulty	.800	44	.828	.064	45	.824	.046
Medium Difficulty	.600	49	.617	.031	47	.610	.041
High Difficulty	.400	49	.434	.103	46	.417	.076

table reveals that tests in each condition achieved the appropriate target proportion correct with a good degree of accuracy. The largest discrepancy (.051) was between the target value of .400 and the actual value of .451 for the low-difficulty conventional test administered with KR.

Table 2
Means and Standard Deviations of Maximum Likelihood Ability Estimates for Conventional and Stradaptive Tests With and Without KR at Three Levels of Difficulty, and Three-Way ANOVA Results

Experimental Condition	Experimental Condition: KR			Experimental Condition: No-KR			Combined Conditions		
	N	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.
Conventional Test									
Low Difficulty	48	-.50	.98	45	-.21	1.00	93	-.36	.99
Medium Difficulty	47	-.38	1.15	49	-.44	.96	96	-.41	1.06
High Difficulty	46	-.21	1.28	46	-.74	1.23	92	-.48	1.28
Stradaptive Test									
Low Difficulty	44	-.24	1.05	45	-.10	.93	89	-.17	.99
Medium Difficulty	49	-.26	.81	47	-.32	.99	96	-.29	.90
High Difficulty	49	-.20	1.13	46	-.31	.98	95	-.26	1.05
Combined Conditions									
Conventional Test	141	-.37	1.14	140	-.46	1.08	281	-.42	1.11
Stradaptive Test	142	-.23	.99	138	-.25	.97	280	-.24	.98
Low Difficulty	92	-.38	1.02	90	-.16	.96	182	-.27	.99
Medium Difficulty	96	-.32	.99	96	-.38	.97	192	-.35	.98
High Difficulty	95	-.21	1.20	92	-.52	1.13	187	-.36	1.17
Total	283	-.30	1.07	278	-.36	1.03	561	-.33	1.05

Three-Way Analysis of Variance

Source of Variation	Sum of Squares	*DF*	Mean Square	*F*	*p**
Main Effects					
KR	.41	1	.41	.38	.999
Test Strategy	4.36	1	4.36	3.98	.044
Difficulty Level	1.05	2	.52	.48	.999
Two-Way Interactions					
KR × Test Strategy	.28	1	.28	.25	.999
KR × Difficulty Level	6.36	2	3.18	2.91	.054
Test Strategy × Difficulty Level	.24	2	.12	.11	.999
Three-Way Interaction					
KR × Test Strategy × Difficulty Level	2.02	2	1.01	.92	.999
Residual	601.18	549	1.10		
Total	615.83	560	1.10		

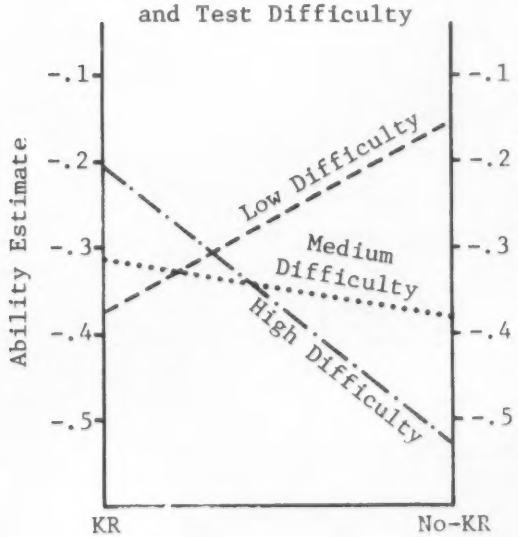
*Estimated probability of error in rejecting null hypothesis.

Maximum likelihood ability estimates. Table 2 shows the means and standard deviations of the maximum likelihood ability estimates as a function of KR

condition, test strategy, and test difficulty. The results of the three-way analysis of variance are also shown. The analysis of variance revealed a significant ($p<.05$) main effect for test strategy. The mean ability estimate for students administered the stradaptive tests (-.24) was significantly higher than the mean for students taking the conventional tests (-.42).

There was also a marginally significant ($p=.054$) two-way interaction between the provision of KR and test-difficulty factors. This interaction is shown graphically in Figure 1. Interestingly, Figure 1 shows that the effects of test difficulty on test performance were opposite in direction, depending on whether or not KR was provided. When KR was provided, the mean student ability estimate was highest on the most-difficult tests (-.21) and lowest on the least-difficult tests (-.38). The mean ability estimate for students in the no-KR conditions was highest on the least-difficult tests (-.16) and lowest on the most-difficult tests (-.52).

Figure 1
Mean Maximum-Likelihood Ability Estimates as a Function of KR-Provision and Test Difficulty



Psychological Reactions to Testing

Difficulty Perception. The means and standard deviations of scores on the Difficulty-Perception scale are shown in Table 3 along with the results of a three-way analysis of variance of these data. The expected main effect due to test difficulty was highly significant ($p<.001$). In addition, the main effect of KR-provision was also significant ($p<.01$). Students receiving KR perceived the tests as being less difficult than did those not receiving KR. The mean Difficulty-Perception score for students in the KR conditions was -.94, while the mean for students in the no-KR conditions was -.13.

Table 3
Means and Standard Deviations of Difficulty-Perception Scores for Conventional and Stradaptive Tests With and Without KR at Three Levels of Difficulty, and Three-Way ANOVA Results

Experimental Condition	Experimental Condition: KR			Experimental Condition: No-KR			Combined Conditions		
	N	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.
Conventional Test									
Low Difficulty	48	-3.59	3.08	45	-2.91	3.24	93	-3.26	3.16
Medium Difficulty	47	-1.13	3.53	49	-.59	3.05	96	-.85	3.29
High Difficulty	46	1.84	4.82	46	3.69	4.44	92	2.76	4.70
Stradaptive Test									
Low Difficulty	44	-4.98	2.46	45	-3.27	2.82	89	-4.12	2.77
Medium Difficulty	49	-.79	2.35	47	-.17	3.00	96	-4.9	2.69
High Difficulty	49	2.69	3.37	46	2.34	3.39	95	2.52	3.37
Combined Conditions									
Conventional Test	141	-1.00	4.44	140	.07	4.50	281	-.46	4.49
Stradaptive Test	142	-.89	4.15	138	-.34	3.82	280	-.62	4.00
Low Difficulty	92	-4.26	2.87	90	-3.09	3.03	182	-3.68	3.00
Medium Difficulty	96	-.95	2.97	96	.38	3.02	192	-.67	3.00
High Difficulty	95	2.27	4.14	92	3.02	3.99	187	2.64	4.07
Total	283	-.94	4.29	278	-.13	4.18	561	-.54	4.25

Three-Way Analysis of Variance

Source of Variation	Sum of Squares	*DF*	Mean Square	*F*	*p**
Main Effects					
KR	94.27	1	94.27	8.33	.004
Test Strategy	7.48	1	7.48	.66	.999
Difficulty Level	3693.13	2	1846.56	163.24	.001
Two-Way Interactions					
KR × Test Strategy	4.82	1	4.82	.43	.999
KR × Difficulty Level	8.96	2	4.48	.40	.999
Test Strategy × Difficulty Level	37.23	2	18.62	1.65	.192
Three-Way Interaction					
KR × Test Strategy × Difficulty Level	63.58	2	31.79	2.81	.059
Residual	6210.13	549	11.31		
Total	10112.87	560	18.06		

*Estimated probability of error in rejecting null hypothesis.

Anxiety. Table 4 shows the means and standard deviations of the Anxiety scale scores as a function of experimental condition and the results of a three-way analysis of variance of these scores. As Table 4 shows, there were no effects of KR-provision, test strategy, or test difficulty on mean Anxiety scores.

Table 4
Means and Standard Deviations of Anxiety Scores
for Conventional and Stradaptive Tests With and Without KR
at Three Levels of Difficulty, and Three-Way ANOVA Results

Experimental Condition	Experimental Condition: KR			Experimental Condition: No-KR			Combined Conditions		
	N	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.
Conventional Test									
Low Difficulty	48	-4.14	2.64	45	-3.70	2.58	93	-3.93	2.61
Medium Difficulty	47	-3.49	3.20	49	-3.45	3.33	96	-3.47	3.25
High Difficulty	46	-3.34	2.88	46	-3.46	3.23	92	-3.40	3.04
Stradaptive Test									
Low Difficulty	44	-3.52	3.09	45	-3.84	3.08	89	-3.68	3.07
Medium Difficulty	49	-4.06	2.94	47	-4.09	3.26	96	-4.08	3.08
High Difficulty	49	-3.72	3.26	46	-3.24	2.84	95	-3.48	3.06
Combined Conditions									
Conventional Test	141	-3.67	2.91	140	-3.53	3.05	281	-3.60	2.98
Stradaptive Test	142	-3.77	3.08	138	-3.73	3.07	280	-3.75	3.07
Low Difficulty	92	-3.84	2.86	90	-3.77	2.83	182	-3.81	2.84
Medium Difficulty	96	-3.78	3.06	96	-3.77	3.30	192	-3.77	3.17
High Difficulty	95	-3.54	3.07	92	-3.35	3.02	187	-3.44	3.04
Total	283	-3.72	3.00	278	-3.63	3.06	561	-3.67	3.02

Three-Way Analysis of Variance

Source of Variation	Sum of Squares	*DF*	Mean Square	*F*	*p**
Main Effects					
KR	1.16	1	1.16	.13	.999
Test Strategy	3.31	1	3.31	.36	.999
Difficulty Level	15.30	2	7.65	.83	.999
Two-Way Interactions					
KR × Test Strategy	.20	1	.20	.02	.999
KR × Difficulty Level	.85	2	.42	.05	.999
Test Strategy × Difficulty Level	17.23	2	8.61	.93	.999
Three-Way Interaction					
KR × Test Strategy × Difficulty Level	10.66	2	5.33	.58	.999
Residual	5067.31	549	9.23		
Total	5115.72	560	9.14		

*Estimated probability of error in rejecting null hypothesis.

Motivation. The means and standard deviations of the Motivation scores as a function of experimental condition are indicated in Table 5. A three-way analysis of variance of these data, also shown in Table 5, indicated a significant ($p<.05$) main effect for the KR factor. The mean Motivation score for individuals receiving KR (.10) was significantly higher than that for individuals not receiving KR (-.32). No other main effects or interactions were statistically significant.

Table 5
Means and Standard Deviations of Motivation Scores for Conventional and Stradaptive Tests With and Without KR at Three Levels of Difficulty, and Three-Way ANOVA Results

Experimental Condition	Experimental Condition: KR			Experimental Condition: No-KR			Combined Conditions		
	N	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.
Conventional Test									
Low Difficulty	48	.08	2.49	45	.07	1.92	93	.07	2.22
Medium Difficulty	47	-.01	2.31	49	-.01	2.33	96	-.01	2.31
High Difficulty	46	.33	1.96	46	-.70	2.14	92	-.18	2.11
Stradaptive Test									
Low Difficulty	44	.24	2.34	45	-.49	2.10	89	-.13	2.24
Medium Difficulty	49	.12	1.97	47	-.55	2.26	96	-.20	2.13
High Difficulty	49	-.16	2.08	46	-.25	2.25	95	-.21	2.15
Combined Conditions									
Conventional Test	141	.13	2.26	140	-.21	2.16	281	-.04	2.21
Stradaptive Test	142	.06	2.12	138	-.43	2.19	280	-.18	2.17
Low Difficulty	92	.16	2.40	90	-.21	2.02	182	-.03	2.22
Medium Difficulty	96	.06	2.13	96	-.27	2.30	192	-.11	2.22
High Difficulty	95	.08	2.03	92	-.48	2.19	187	-.20	2.12
Total	283	.10	2.19	278	-.32	2.17	561	-.11	2.19

Three-Way Analysis of Variance

Source of Variation	Sum of Squares	*DF*	Mean Square	*F*	*p**
Main Effects					
KR	24.37	1	24.37	5.10	.023
Test Strategy	2.78	1	2.78	.58	.999
Difficulty Level	2.63	2	1.32	.28	.999
Two-Way Interactions					
KR × Test Strategy	.79	1	.79	.17	.999
KR × Difficulty Level	1.38	2	.69	.14	.999
Test Strategy × Difficulty Level	.85	2	.42	.09	.999
Three-Way Interaction					
KR × Test Strategy × Difficulty Level	21.06	2	10.53	2.20	.999
Residual	2623.82	549	4.78		
Total	2677.69	560	4.78		

*Estimated probability of error in rejecting null hypothesis.

Reactions to KR. Table 6 shows the means and standard deviations of scores on the KR-Reaction scale as a function of test strategy and test difficulty for students in the KR conditions. Table 6 also shows the results of a two-way analysis of variance of these data. There were no significant effects of experimental condition on mean KR-Reaction scores.

The endorsement frequencies of response options on the KR-Reaction items are shown in Table 7. Of the 283 students receiving KR, 87% said that KR made the test much more interesting, 86% felt that KR did not interfere

Table 6
Means and Standard Deviations of KR-Reaction Scores for Conventional and Stradaptive Tests at Three Levels of Difficulty, and Two-Way ANOVA Results

Experimental Condition	*N*	Mean	S.D.
Conventional Test			
Low Difficulty	48	-1.16	1.62
Medium Difficulty	47	-.92	1.59
High Difficulty	46	-1.26	1.90
Stradaptive Test			
Low Difficulty	44	-.42	.83
Medium Difficulty	49	-.99	2.12
High Difficulty	49	-1.39	2.30
Combined Conditions			
Conventional Test	141	-1.11	1.70
Stradaptive Test	142	-.95	1.92
Low Difficulty	92	-.80	1.35
Medium Difficulty	96	-.95	1.87
High Difficulty	95	-1.32	2.11
Total	283	-1.03	1.81

Two-Way Analysis of Variance

Source of Variation	Sum of Squares	*DF*	Mean Square	*F*	*p**
Main Effects					
Test Strategy	2.11	1	2.11	.65	.999
Difficulty Level	13.72	2	6.86	2.11	.121
Two-Way Interaction					
Test Strategy × Difficulty Level	10.84	2	5.42	1.66	.189
Residual	901.68	277	3.26		
Total	928.07	282	3.29		

*Estimated probability of error in rejecting null hypothesis.

with their ability to concentrate on the test, 76% reported that KR did not make them "nervous," and 81% were very interested in knowing whether their answers were right or wrong. Ninety-two percent of the students receiving KR indicated that they liked getting immediate feedback.

Table 7
Relative Frequencies of Response Option Endorsement for KR-Reaction Items (N=283)

Item	Relative Frequency of Response Option Endorsement
Did getting feedback on this test make it more interesting or less interesting?	
1. Much more interesting	.87
2. Somewhat more interesting	.11
3. Didn't make any difference	.00
4. Somewhat less interesting	.01
5. Much less interesting	.01
Did receiving feedback after each question interfere with your ability to concentrate on the test?	
1. No, not at all	.86
2. Yes, somewhat	.12
3. Yes, moderately so	.04
4. Yes, very much so	.02
Did getting feedback after each question make you nervous?	
1. No, not at all	.76
2. Yes, somewhat	.22
3. Yes, moderately so	.01
4. Yes, very much so	.01
Were you interested in knowing whether your answers were right or wrong?	
1. I was very interested	.81
2. I was moderately interested	.14
3. I was somewhat interested	.04
4. I didn't care at all	.00
How do you feel about getting feedback?	
1. I'd rather not know whether my answers were right or wrong	.07
2. I really don't care whether I get feedback or not	.01
3. I liked getting the feedback	.92

Interrelationships of psychological scales. The reliabilities of the Difficulty-Perception, Anxiety, Motivation, and KR-Reaction scales are shown in the diagonal of the matrix in Table 8. The off-diagonal entries in the matrix are the Pearson product-moment correlations among the four scales. The correlations involving the KR-Reaction scale are based on the 283 students in the KR conditions, whereas the other correlations are based on all 561 students. As the perceived difficulty of the test increased, Anxiety scores increased and Motivation scores decreased. Anxiety was positively but modestly correlated with Motivation. Reactions to KR became more positive as the Perceived Difficulty of the test decreased, and Motivation was positively correlated with positive reactions to KR.

Table 8
Reliabilities and Intercorrelations of
Psychological Reactions Scales

Scale	Difficulty-Perception	Anxiety	Motivation	KR-Reaction
Difficulty-Perception	*.89*			
Anxiety	.21	*.78*		
Motivation	-.17	.13	*.62*	
KR-Reaction	-.15	-.16	.25	*.66*

Note. All correlations statistically significant at $p \leq .05$.

Discussion

Betz and Weiss (1976a) found that the provision of KR increased the average maximum likelihood ability estimate of students administered a stradaptive or a conventional peaked test. They also found that KR increased the average number-correct score on the conventional test. The present data did not replicate these findings. In this study the average ability estimate of students in the KR and the average of students in the no-KR conditions did not differ significantly; nor did the present data show a higher level of anxiety on the adaptive test--a finding reported in Betz and Weiss (1976b).

In this study, the mean maximum likelihood ability estimate was higher on the adaptive test than on the conventional test. In addition, the data suggest that average motivation is increased by the provision of KR. This latter effect may be partially due to the fact that students not provided KR rated the tests as more difficult than did students receiving KR. In addition, Motivation scale scores and scores on the Difficulty-Perception scale had a significant but modest negative correlation.

Prestwood and Weiss (1977) analyzed student perceptions of individual item difficulties and showed that items with difficulties somewhat below the ability levels of the students were, on the average, perceived as being "about right" in difficulty. They suggested that by tailoring tests so that the item difficulties are psychometrically optimal, adaptive strategies may also be tailoring tests so that, in effect, all of the items are perceived by testees as being too difficult. They concluded that the psychological effects of such a procedure should be investigated more fully. The data reported here show no significant effects on mean level of anxiety or motivation due to test difficulty alone. These data suggest that although students perceive items below their level of ability as being most appropriate in difficulty, these perceptions do not adversely affect motivation when test difficulty is in the range employed in this study (proportion correct of .40 to .80).

The marginally significant but highly provocative interaction of test difficulty and KR-provision in the analysis of maximum likelihood ability estimates indicates that the provision of KR may affect the performance of individuals differentially, depending on the difficulty of the task. On a conventional test, individual students may receive different tests in a psychological sense. Although each student will receive the same items, low-ability students may be responding to a relatively "difficult" test, whereas

high-ability students may be responding to a relatively "easy" test. If the provision of KR has differential effects depending on the difficulty of the task, students of different ability levels may respond differently to the provision of KR according to their perceptions of the task's difficulty, even though they are administered the same set of test items.

On an adaptive test, where the difficulty of the task is modified so that each individual answers approximately the same proportion of items correctly, the differential effects of KR and test difficulty should be minimized. Although students react very favorably to KR regardless of the proportion of positive feedback they received, the interaction of test difficulty and KR-provision in the analysis of ability estimates suggests that the effects of KR's provision on *performance* should be carefully investigated before KR is provided under new sets of conditions.

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Appendix: Supplementary Tables

Table A
Difficulty-Perception Items, Serial Position of Administration, and Weights Assigned to Response Alternatives

Item and Response Alternatives	Serial Position	Assigned Weight
How often did you feel that the questions in the test were too easy for you?	1	
1. Always		1.00
2. Frequently		2.00
3. Sometimes		3.00
4. Seldom		4.00
5. Never		5.00
How often did you feel that the questions in the test were too hard for you?	2	
1. Always		-1.00
2. Frequently		-2.00
3. Sometimes		-3.00
4. Seldom		-4.00
5. Never		-5.00
On how many of the questions did you guess?	5	
1. Almost all of the questions		-1.00
2. More than half of the questions		-1.80
3. About half of the questions		-2.60
4. Less than half of the questions		-3.40
5. Almost none of the questions		-4.20
6. None of the questions		-5.00
How often were you sure that your answers to the questions were correct?	8	
1. Almost always		1.00
2. More than half of the time		2.00
3. About half of the time		3.00
4. Less than half of the time		4.00
5. Almost never		5.00
In relation to your vocabulary ability, how difficult was the test for you?	10	
1. Much too difficult		-1.00
2. Somewhat too difficult		-2.00
3. Just about right		-3.00
4. Somewhat too easy		-4.00
5. Much too easy		-5.00
Did you feel frustrated by the difficulty of the test questions?		
1. Not at all	12	1.00
2. Somewhat		2.33
3. Fairly much so		3.67
4. Very much so		5.00

Table B
Anxiety Items, Serial Position of Administration, and Weights Assigned to Response Alternatives

Item and Response Alternatives	Serial Position	Assigned Weight
During testing, did you worry about how well you would do?	4	
1. Not at all		1.00
2. Somewhat		2.33
3. Fairly much so		3.67
4. Very much		5.00
Were you nervous while taking the test?	7	
1. Not at all		1.00
2. Somewhat		2.33
3. Moderately so		3.67
4. Very much so		5.00
How did you feel while taking the test?	11	
1. Very tense		-1.00
2. Somewhat tense		-2.00
3. Neither tense nor relaxed		-3.00
4. Somewhat relaxed		-4.00
5. Very relaxed		-5.00
Did nervousness while taking the test prevent you from doing your best?	16	
1. Yes, definitely		-1.00
2. Yes, somewhat		-2.33
3. Probably not		-3.67
4. Lefinitely not		-5.00

Table C
Motivation Items, Serial Position of Administration, and Weights Assigned to Response Alternatives

Item and Response Alternatives	Serial Position	Assigned Weight
How frequently were you careful to select what you thought was the best answer to each question?	6	
1. Almost always		-1.00
2. Frequently		-2.00
3. Sometimes		-3.00
4. Rarely		-4.00
5. Never		-5.00
Did you feel challenged to do as well as you could on the test?	13	
1. Not at all		1.00
2. Somewhat		2.33
3. Fairly much so		3.67
4. Very much so		5.00
Did you care how well you did on the test?	18	
1. I cared a lot		-1.00
2. I cared some		-2.00
3. I cared a little		-3.00
4. I cared very little		-4.00
5. I didn't care at all		-5.00

Table D
KR-Reaction Items, Serial Position of Administration, and Weights Assigned to Response Alternatives

Item and Response Alternatives	Serial Position	Assigned Weight
Did getting feedback on this test make it more interesting or less interesting?	19	
1. Much more interesting		-1.00
2. Somewhat more interesting		-1.75
3. Didn't make any difference		-2.50
4. Somewhat less interesting		-3.25
5. Much less interesting		-4.00
Did receiving feedback after each question interfere with your ability to concentrate on the test?	20	
1. No, not at all		-1.00
2. Yes, somewhat		-2.00
3. Yes, moderately so		-3.00
4. Yes, very much so		-4.00
Did getting feedback after each question make you nervous?	21	
1. No, not at all		-1.00
2. Yes, somewhat		-2.00
3. Yes, moderately so		-3.00
4. Yes, very much so		-4.00
Were you interested in knowing whether your answers were right or wrong?	24	
1. I was very interested		-1.00
2. I was moderately interested		-2.00
3. I was somewhat interested		-3.00
4. I did not care at all		-4.00
How do you feel about getting feedback?	26	
1. I'd rather not know whether my answers were right or wrong		1.00
2. I really don't care whether I get feedback or not		2.50
3. I liked getting the feedback		4.00

Table E
Normal-Ogive Discrimination (a) and Difficulty (b)
Parameters of Items on the Three 50-Item Conventional Tests

Low-Difficulty Test			Medium-Difficulty Test			High-Difficulty Test		
Item Reference Number	a	b	Item Reference Number	a	b	Item Reference Number	a	b
20	.38	-5.76	23	.71	-3.86	262	.77	-1.93
72	.27	-6.13	18	.48	-4.24	31	.72	-2.14
4	.40	-5.56	240	.59	-3.35	641	.58	-1.40
29	.32	-5.52	212	.56	-3.64	559	.62	-1.68
62	.43	-4.95	16	.75	-2.95	285	.84	-1.02
78	.44	-4.84	100	.59	-3.18	640	.78	-1.06
55	.29	-4.95	201	.31	-2.97	26	.36	-1.02
23	.71	-3.86	65	1.02	-2.71	43	1.11	-.86
18	.48	-4.24	89	.72	-2.49	149	.83	-.46
122	1.15	-3.31	124	1.09	-2.64	87	1.24	-.76
32	.66	-3.73	63	.69	-2.14	33	.80	-.39
2	.52	-3.81	131	.60	-2.58	183	.73	-.45
212	.56	-3.64	106	.67	-2.01	207	.79	-.04
77	.44	-3.60	81	.44	-2.39	157	.38	-.25
8	1.01	-3.15	186	1.07	-1.34	599	1.63	.16
39	.35	-3.63	256	.46	-1.93	205	.60	-.02
19	.71	-3.81	559	.62	-1.68	144	.91	.29
182	.70	-3.83	34	.83	-1.58	568	1.63	.29
105	.98	-2.63	127	1.08	-1.35	283	3.00	.49
261	.42	-3.46	276	.45	-1.53	318	.53	.31
16	.75	-2.95	285	.84	-1.02	340	1.92	.65
187	.48	-3.07	94	.56	-1.02	506	.81	.58
121	.74	-2.82	85	.93	-.67	114	3.00	.96
69	.53	-3.23	241	.57	-1.05	271	.89	.80
126	.96	-2.27	522	1.06	-.39	541	3.00	1.16
131	.60	-2.58	222	.65	-.50	526	1.17	.92
66	.87	-2.02	270	1.22	-.14	665	3.00	1.62
63	.69	-2.14	156	.84	-.17	321	3.00	1.00
262	.77	-1.93	56	1.11	.14	120	3.00	1.46
95	.56	-1.71	444	.62	.06	306	1.32	1.20
90	.94	-1.31	568	1.63	.29	174	3.00	1.46
186	1.07	-1.34	266	2.12	.51	254	3.00	1.37
276	.45	-1.53	629	.53	.42	147	.83	1.47
214	.48	-1.49	377	.59	.39	586	1.54	1.31
322	.67	-1.09	113	1.06	.68	652	3.00	1.66
235	.66	-.78	271	.89	.80	595	3.00	1.58
349	.92	-.52	114	3.00	.96	573	3.00	1.86
123	.82	-.56	294	3.00	1.07	319	3.00	2.14
287	.52	-.65	111	.82	.94	400	.93	1.68
94	.56	-1.02	506	.81	.58	263	3.00	1.47
234	.65	-.13	601	1.22	1.10	445	3.00	2.07
597	.62	-0	299	1.77	1.16	383	2.11	1.52
145	.79	.09	581	1.26	1.21	247	.65	2.06
292	.61	.01	306	1.32	1.20	273	3.00	2.14
635	.57	.27	304	.89	1.34	115	3.00	2.02
622	.44	.20	367	.72	1.40	533	.63	2.15
506	.81	.58	140	3.00	1.38	381	3.00	2.35
165	.38	.56	286	.59	1.64	534	2.52	1.61
113	1.06	.68	595	3.00	1.58	360	3.00	1.71
526	1.17	.92	573	3.00	1.86	609	3.00	2.14
Mean	.65	-2.33	Mean	1.07	-.70	Mean	1.76	.68
S.D.	.23	1.91	S.D.	.73	1.71	S.D.	1.05	1.21

Table F
Normal-Ogive Discrimination (a) and Difficulty (b) Parameters for Items in the Stratified Item Pool

Item Reference Number	a	b	Item Reference Number	a	b	Item Reference Number	a	b
Stratum 1			Stratum 2 (cont'd)			Stratum 4 (cont'd)		
573	3.00	1.86	119	.53	1.73	386	1.25	.54
595	3.00	1.58	281	.40	1.79	538	1.18	.52
263	3.00	1.47	603	.38	1.80	60	1.23	.64
378	3.00	1.48	Mean	1.37	1.44	59	1.09	.60
561	1.72	1.42	S.D.	.98	.18	113	1.06	.68
572	1.29	1.43				551	.90	.34
253	2.32	1.44	Stratum 3			146	.93	.47
168	.91	1.55	583	3.00	1.16	636	.76	.37
260	.71	1.82	337	3.00	1.18	271	.89	.80
400	.93	1.68	541	3.00	1.16	506	.81	.58
521	.75	1.70	114	3.00	.96	295	.68	.53
504	.64	1.81	294	3.00	1.07	233	.65	.41
616	.61	1.76	321	3.00	1.00	267	.65	.77
403	.54	1.76	607	3.00	1.11	139	.61	.79
577	.61	2.00	526	1.17	.92	133	.57	.56
374	.56	1.99	651	1.09	.89	258	.57	.64
167	.42	2.16	601	1.32	1.10	593	.56	.55
Mean	1.41	1.70	598	1.08	1.04	519	.53	.44
S.D.	.99	.22	111	.82	.94	289	.48	.69
			375	.83	.93	549	.43	.35
Stratum 2			215	.91	1.07	252	.42	.47
665	3.00	1.62	231	.87	1.19	Mean	1.14	.55
120	3.00	1.46	238	.76	1.13	S.D.	.70	.13
254	3.00	1.37	164	.69	1.14			
288	3.00	1.26	341	.63	1.28	Stratum 5		
562	3.00	1.22	368	.46	1.42	380	1.82	.12
617	2.78	1.17	576	.43	1.13	272	1.96	.22
299	1.77	1.16	213	.43	1.43	599	1.63	.16
140	3.00	1.38	259	.37	1.29	568	1.63	.29
306	1.32	1.20	172	.38	1.36	329	1.42	.18
581	1.26	1.21	516	.35	1.12	161	1.38	.13
291	1.64	1.35	333	.35	1.34	270	1.22	-.14
217	1.25	1.38	308	.34	1.31	128	1.07	-.36
304	.89	1.34	Mean	1.32	1.14	143	1.04	-.15
587	.87	1.36	S.D.	1.05	.15	37	.86	-.24
147	.83	1.47				156	.84	-.17
367	.72	1.40	Stratum 4			221	.82	-.28
216	.67	1.40	347	3.00	.49	209	.87	.07
397	.65	1.34	296	3.00	.67	144	.91	.29
610	.79	1.57	266	2.12	.51	211	.77	-.24
159	.77	1.56	264	2.28	.55	52	.84	.21
107	.69	1.59	340	1.92	.65	207	.79	-.04
525	.57	1.51	342	1.59	.54	208	.74	-.18
286	.59	1.64	265	1.57	.55	369	.79	.30
242	.52	1.57	301	1.38	.47	307	.70	-.33
505	.50	1.43	582	1.20	.35	224	.68	-.26

(continued)

Table F (*cont'd*)

Item Reference Number	*a*	*b*
Stratum 5 (cont'd)		
502	.73	.22
50	.69	.32
391	.62	.06
292	.61	.01
205	.60	-.02
355	.51	.10
218	.41	-.13
234	.65	-.13
157	.38	-.25
Mean	.93	-.01
S.D.	.40	.21
Stratum 6		
194	1.79	-.96
36	1.64	-.79
40	1.24	-1.03
87	1.24	-.76
501	1.20	-.55
199	1.09	-1.09
43	1.11	-.86
109	1.11	-.70
47	1.04	-.96
522	1.06	-.39
239	.94	-.71
173	.88	-1.06
85	.93	-.67
204	.88	-.74
123	.82	-.56
46	.84	-.36
203	.82	-.38
33	.80	-.39
535	.77	-.37
183	.73	-.45
185	.68	-.68
235	.66	-.78
222	.65	-.50
117	.62	-.66
112	.61	-.78
53	.64	-.48
94	.56	-1.02
546	.56	-.80
287	.52	-.65
371	.44	-.92
Mean	.90	-.70
S.D.	.31	.22
Stratum 7		
196	2.13	-1.79
190	1.82	-1.44
27	1.43	-1.68
84	1.70	-1.64
13	1.89	-1.55
96	1.13	-1.72
125	1.24	-1.88
129	1.27	-1.35
22	1.20	-1.97
101	1.17	-1.40
44	1.15	-1.41
134	1.07	-1.94
127	1.08	-1.35
186	1.07	-1.34
90	.94	-1.31
83	.88	-1.45
86	.89	-1.19
34	.83	-1.58
227	.81	-1.25
262	.77	-1.93
311	.75	-1.43
189	.76	-1.19
88	.71	-1.33
232	.67	-1.25
76	.62	-1.75
95	.56	-1.71
108	.54	-1.16
214	.48	-1.49
141	.48	-1.21
276	.45	-1.53
Mean	1.02	-1.51
S.D.	.43	.24
Stratum 8		
99	1.24	-2.67
11	1.75	-2.58
9	1.45	-2.24
102	3.00	-2.36
71	3.00	-2.32
138	1.73	-2.02
70	1.29	-2.24
124	1.09	-2.64
206	1.11	-2.19
158	1.08	-2.00
65	1.02	-2.71
181	1.02	-2.58
105	.98	-2.63
126	.96	-2.26
66	.87	-2.02
80	.86	-2.25
198	.80	-2.50
5	.75	-2.16
89	.72	-2.49
184	.73	-2.19
31	.72	-2.14
63	.69	-2.14
106	.67	-2.01
255	.64	-2.18
202	.62	-2.17
131	.60	-2.58
628	.57	-2.29
82	.54	-2.31
151	.44	-2.65
73	.43	-2.69
Mean	1.05	-2.34
S.D.	.62	.23
Stratum 9		
28	3.00	-2.63
25	3.00	-2.63
122	1.15	-3.31
8	1.01	-3.15
121	.74	-2.82
16	.75	-2.95
17	.72	-2.89
32	.66	-3.73
100	.59	-3.18
240	.59	-3.35
212	.56	-3.64
69	.53	-3.23
187	.48	-3.06
261	.42	-3.46
135	.43	-2.79
74	.39	-3.24
132	.38	-3.21
30	.31	-3.58
201	.31	-2.97
570	.29	-3.14
48	.27	-2.70
Mean	.79	-3.13
S.D.	.75	.31

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